Demand Access System Description and Operations Concept (DASDOC)

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Greenbelt, Maryland

Demand Access Service:
System Description and Operations Concept

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Preface

This document was produced for the MO&DSD Networks Division, Code 450, and will be controlled by the Demand Access Project Manager.

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1. INTRODUCTION

1.1 Background and Scope

Conventional Tracking and Data Relay Satellite System (TDRSS) operations provide the Space Network (SN) user with service based on a schedule generated from user requests. Normally completed days in advance, this schedule is based upon estimates of user needs and mission event timelines. The need to provide timely SN service to smaller missions and at a reduced cost makes a more efficient service allocation more desirable. The Demand Access System (DAS), provides automated service-on-demand. This benefits not only the SN user, but also the SN itself, with low implementation cost and no change in the existing TDRSS-spacecraft. The TDRSS Multiple Access (MA) service was selected for Demand Access (DA) support for the following reasons:

- it supports multiple users simultaneously,
- it offers a low cost approach to providing expanded TDRSS service, and
- MA service resources are currently underused.

This document describes:

- how the DAS will augment the communications capabilities currently available to users of the TDRSS MA services,
- the types of DAS services available,
- how the DAS users will interface operationally with the system, and
- some of the operational scenarios associated with the DA services.

1.2 Document Organization

The document is divided into five sections as summarized below.

- Introduction - Section 1 describes the scope and organization of the document
- TDRSS MA System Overview - Section 2 of the document describes the current MA system that provides the basis for the upgrade known as the DAS. The architecture, services, scheduling activities, and limitations are summarized to provide the reader with a basis for understanding the DAS
- DAS Description - Section 3 of the document describes the architecture, services, and high-level scheduling aspects associated with the DAS
- DA Operations - Section 4 provides a summary of the operational details associated with the DAS user and DAS component interactions required to plan, execute, and terminate the DA service options
- Operational Scenario Example - Section 5 provides an expanded example of the operational interactions associated with the establishment of one service
- Acronyms and Abbreviations - Section 6 contains a list of all of the acronyms and abbreviations used in this document.

2. TDRSS MA SERVICE OVERVIEW

2.1 Introduction

The SN portion of NASA's Spaceflight Tracking and Data Network (STDN) provides reliable two-way telecommunications traffic between suborbital and low earth-orbiting spacecraft and their ground-based Project Operations Control Centers (POCCs). As shown in Figure 2-1, these communications are accomplished by relaying data through the geostationary TDRSS spacecraft. The Tracking and Data Relay Satellites (TDRSs) comprise the space segment of the SN. The equipment in the ground segment of the SN performs the support functions necessary to complete the connection with the TDRSS user POCC. Ground Terminals (GTs) located at White Sands Complex (WSC) and Guam[1] have line of sight contact with TDRSS spacecraft stationed to provide global communications coverage. This makes it possible for the user POCCs to maintain contact with their platforms at any time provided that they are allocated TDRSS communications services for the appropriate TDRSS satellites and GTs. TDRSS users obtain scheduled services through the Network Control Center (NCC). The NCC manages the TDRSS resources and constructs schedules in conjunction with TDRSS users service requests. Six services are available to the TDRSS user:

- S-band Single Access (SSA) forward and return
- Ku-band Single Access (KSA) forward and return
- Multiple Access (MA) forward and return.

The TDRSS provides forward service of command and data messages from the user POCC to the user satellite (USAT) and an ordinarily much larger data flow return service of telemetry from the USAT to the user POCC. The return telemetry consists of science data and spacecraft data such as equipment status as well as ranging and other orbit determination data. Each TDRS has two large parabolic dish antennas that provide high data rates for Single Access (SA) services. SA services support one user at a time per antenna. These high gain antennas are used for telecommunications at either Ku-band or S-band frequencies. Both KSA and SSA forward (KSAF and SSAF) and return (KSAR and SSAR) services are supported under SA communications.

A phased array antenna provides the MA service at lower data rates than the SA services. The MA service is restricted to the S-band frequency range and can support MA forward (MAF) links used to send commands and data from the user POCC to a single user platform. Currently, the MA return (MAR) service per TDRS can simultaneously transport data from a maximum of five user platforms[2] (UPs) to their respective user POCCs via a single TDRSS spacecraft. MAF and MAR services can be allocated simultaneously. Among the six types of services, the MAR services are the most underutilized. Expanding these services to simultaneously handle more users per unit time will increase the efficiency and cost effectiveness of the system from the perspective of a growing TDRSS user community.

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[1] The Guam ground terminal is scheduled to become operational in the summer of 1998.

[2] User platforms consist of USATs, aircraft, balloons, and any other user managed asset capable of communicating with a TDRS on a MA service.

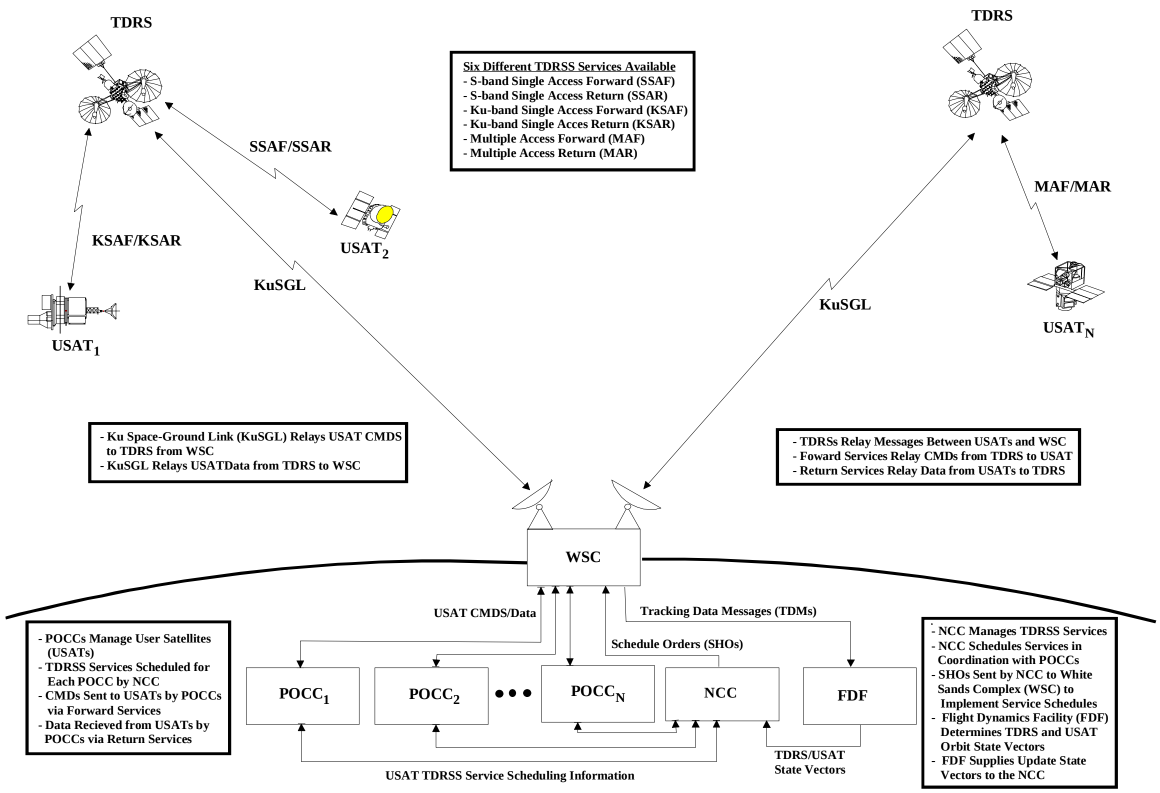

Figure 2-1: TDRSS Architecture

2.2 TDRSS User MA Services

The TDRSS user has a choice between three groups of communications services: SSA, KSA, and MA services. The three services have both forward and return message transmission capabilities to and from the user platform, respectively. The MAF service is similar to the SSAF and KSAF services in the sense that all three are single access. Service acquisition time is shorter for the MA services since the beamforming associated with instituting this service occurs via an electronic reconfiguration of the MA phase array antenna while the SSA and KSA services require the mechanical slewing of the parabolic antenna from one orientation to another. Figure 2-2 shows a TDRS spacecraft and the antenna systems that are used by the SSA, KSA, and MA services. The Space Ground Link (SGL) Antenna for TDRS to Space Ground Link Terminal[3] (SGLT) communications is also shown in this figure.

[3] Five operational SGLTs exist at the WSC and one at Guam.

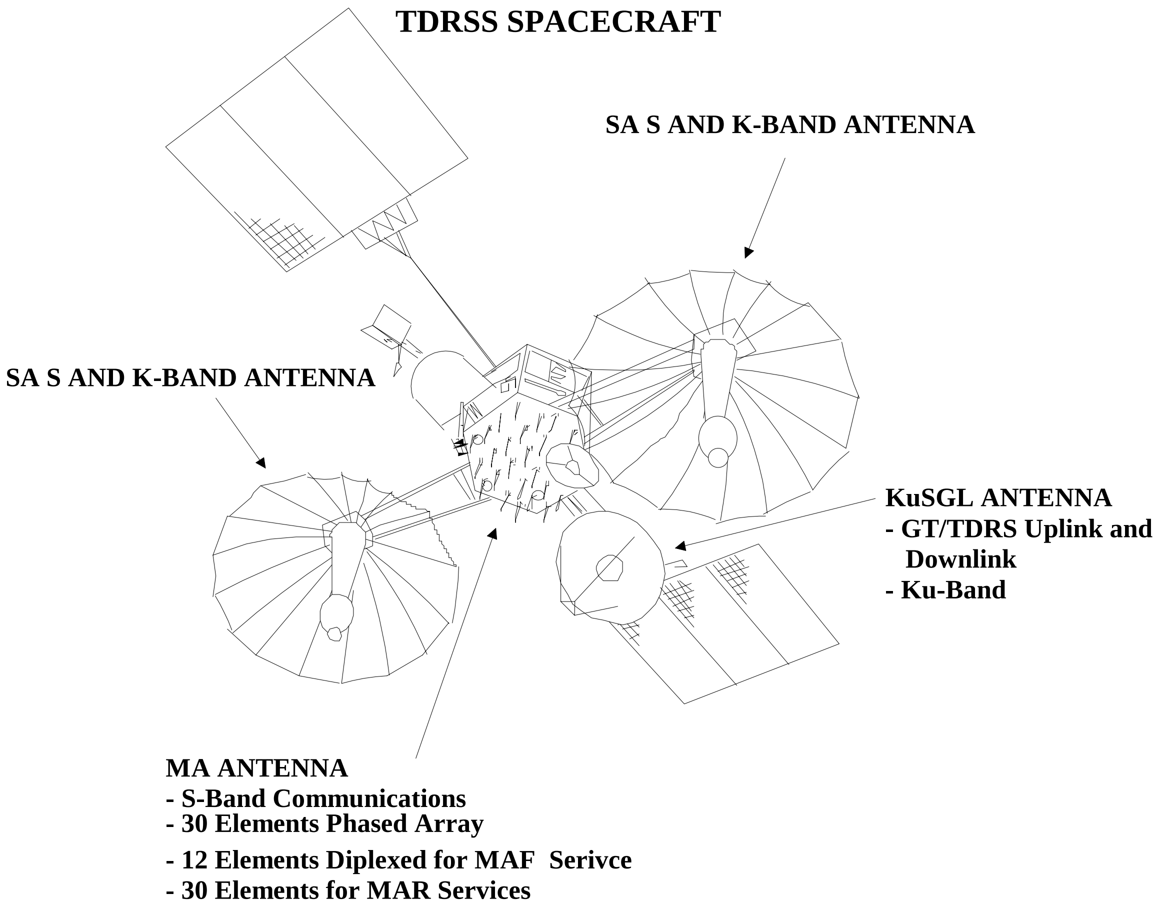

Figure 2-2: TDRSS Spacecraft Antenna Systems

The phased array beamforming capability of the MA antenna allows a single MAF beam or multiple MAR beams to be formed. The SGLT calculates the phase shifts associated with the MA elements to achieve a specific antenna footprint that coincides with the UP. TDRS and UP navigation information maintained by the Flight Dynamics Facility (FDF) allows the SGLT to continually update the phases that are applied to the MA antenna elements in order to steer the beam. The pointing of the beam's bore sight coincides with the continually changing position of the UP as a function of time. Both forward and return MA service beams can be constructed and managed in this manner.

2.2.1 MAF Service

The MAF service consists of command and message data from a user POCC pseudorandom noise (PN) encoded on a signal uplinked from the SGLT to a TDRS and down-converted to S-band for transmission to the UP via the MA antenna. The MA antenna is configured such that the main lobe of the formed beam generated by the phasing array element points at the UP throughout the duration of the scheduled service. Antenna element phase delays are determined at the SGLT and uplinked to the TDRS via the SGL in parallel with the user's command data.

The continual uplinking of new phase delay data allows the antenna pattern generated by the forward service antenna elements to dynamically change, thus moving the central lobe in a continuous fashion. This form of electronic beam steering allows a moving UP to receive command data as long as the platform is within the line of sight of the TDRSS spacecraft. One MAF service at a time can currently be allocated.

2.2.2 MAR Service

The MAR return service consists of a signal transmission from a UP to the TDRSS spacecraft at S-band where it is upconverted to Ku-band and downlinked to the SGLT. UP MAR signals are resolved by the use of signal PN encoding and MA antenna beamforming processing that resides in the SGLT. Each UP has its own unique pseudorandom noise PN code. The demodulator in the SGLT equipment chain assigned to the service uses the PN code to identify the correct signal for demodulation.

MAR service beamforming capabilities are implemented in the SGLT. S-band signals from a UP that are intercepted by the MA antenna elements are sent to the SGLT for phase adjustment processing. Knowledge of the TDRS and UP locations allows phase delay values to be calculated that can be applied to each of the 30 antenna element signals to construct a resultant signal with a 30-fold improved gain.

Unlike the SSA and KSA services, the MAR service allows up to five users to return data to their associated POCCs at the same time from a single TDRS. This is attributed to the simultaneous, ground-based beamforming capability for MAR services and the use of unique PN codes by the UPs. While MAR services can support more users than the alternative single user SSAR and KSAR services, it supports lower data transmission rates. Thus, users with high return data requirements (e.g., greater than 100 kbps) will choose the SSAR or KSAR services over the MAR service.

2.2.3 MA Tracking Service

MA tracking services are used to supply the FDF with the data necessary to obtain the state vectors for the TDRSS and user spacecraft. The MA tracking options are divided between range and Doppler services. These services are subdivided between one-way return and two-way measurement types. One-way measurements use the MAR service and are restricted to Doppler measurement types. One-way Doppler measurements require that the USAT have an on-board ultrastable oscillator as a frequency reference. Outputs from the demodulators in the GTs are directed to Doppler extractors that measure the frequency of the one-way MAR signal. The output of each Doppler extractor is sent from the GT to the FDF via a Tracking Data Message (TDM). Up to five Doppler return tracking services are available at an SGLT[4].

Two-way range and Doppler measurements are made via the simultaneous scheduling of MAF and MAR services. USAT two-way range measurements are accomplished by making signal round trip elapsed time measurements from the GT to the user spacecraft and back to the GT.

[4] The Guam GT will support two Doppler tracking services at the outset with provisions for future expansion to five.

USAT two-way Doppler measurements use the frequency of the round trip signal as the measured quantity. Both two-way range and Doppler measurements require that the USAT have a two-way phase coherent turn-around transponder on-board. TDMs for both of these two-way measurement types are sent to the FDF to support USAT orbit determination. Due to the limitations of one MAF service at a time, only one MA two-way tracking service can be allocated at a time per TDRS. Both the range and Doppler measurements can be made simultaneously on the same two-way service.

2.3 Scheduling MA Services

Like the SSA, and KSA services, MA services are scheduled through a series of interactions between the user POCC and the NCC. User POCCs submit their preliminary schedule requests to the NCC forecast schedule center at least two weeks prior to the implementation of the forecast schedule. User requests are entered onto the forecast schedule in a prioritized manner based on user rank in the order of access to TDRSS services. The forecast schedule construction goes through a series of iterations in order to attempt to optimize the resource utilization with dynamically changing user service requirements. The final forecast schedule is generated and published one week prior to its implementation. At the time of implementation, it becomes the active schedule for that week. During the active schedule period, MA users can request that additional time slots be made available for their MAF and MAR services during the intervals when there are no MA services scheduled. These service reconfigurations require direct phone and fax-based coordination between the user POCCs and the NCC active scheduling center.

2.4 MA Service Limitations and Operations Alternatives

MA services are constrained by the following features of the existing TDRSS:

- Only one MAF service can be scheduled at a time per TDRS
- Up to five MAR services can be scheduled simultaneously per TDRS.

The MAF constraint cannot be relaxed due to the hardware design of the TDRSS spacecraft. However, there is no limit on the number of return UP signals that can be received by the TDRSS spacecraft. The beamforming and demodulation equipment located in the GTs imposes a limit of five simultaneous MAR users per TDRS. Therefore, it is possible to increase the number of simultaneous MAR user services by upgrading hardware and software in the GTs. Modification of the equipment in the GT and streamlining the scheduling of the unused MAF and MAR service time will increase the volume of services from the TDRSS user perspective.

2.5 Augmentation of MA Services via the DAS

An expansion of the existing MA services is desirable in order to allow greater use of the TDRSS resources while using the existing TDRSS spacecraft. The DAS expands the number of MAR users by augmenting the existing beamforming system in the SGLT with an expandable beamforming system that allows more simultaneous users return service than the current MA system supports. This improvement impacts the return service capabilities alone. Furthermore, forward services benefit from an augmentation in scheduling opportunities in the DAS. Unused MAF time on the NCC active schedule is made available to the DAS users in a manner that allows the user to augment the active schedule with last minute requests for MAF services with the aid of a user controlled DA Planning Tool. A description of the DAS and the operations concept are the subject matter of the following sections of this document.

3. DAS DESCRIPTION

The DAS is an upgrade of the TDRSS services using the MA services. The DAS expands the capabilities of the current SGLT MAR beamforming system to handle an increased number of return service users beyond the current limit of five. This is accomplished by the use of new beamforming equipment and the introduction of more demodulators to accommodate the increased TDRSS user load associated with the DAS[5]. DAS forward service allocation occurs at those times when the NCC active schedule does not have MAF requests already occupying the scheduled time slots. The DAS user requests/obtains the unused MAF time through the DAS. The DAS coordinates forward service requests with the NCC while return service requests are handled directly by the DAS, which controls the new beamforming and demodulator assets. The following sections contain a detailed description of the DAS.

3.1 DAS Functional Architecture Overview

Figure 3-1 shows the functional architecture of the DAS. The existing TDRSS elements that form the foundation for the DAS are also shown in this figure. The elements that augment the existing system to form the DAS appear as shaded function blocks and are as follows:

- Third Generation Beam Forming System (TGBFS),
- DA Return Link Data Recovery Subsystem (RLDRS),
- DA Return Control/Monitoring (DARCM) Function,
- DA Buffer (DAB) Function, and
- DA Processor (DAP) Function.

Unlike the current beamforming system (constrained to support a maximum of five simultaneous MAR users per TDRS), the TGBFS is capable of being continually expanded to accommodate a potential increase in the number of simultaneous DAS return service users. The capability of modularly increasing the number of beamformers in the DAS design is coupled with the parallel capability of increasing the number of demodulators required to extract the data from each additional user’s return signal. The TGBFS and the RLDRS operate in conjunction with the existing MA service chains located in each SGLT.

[5]Two SGLTs at the WSC and the one at Guam will be upgraded to support DA services with provisions for future expansion to all at WSC.

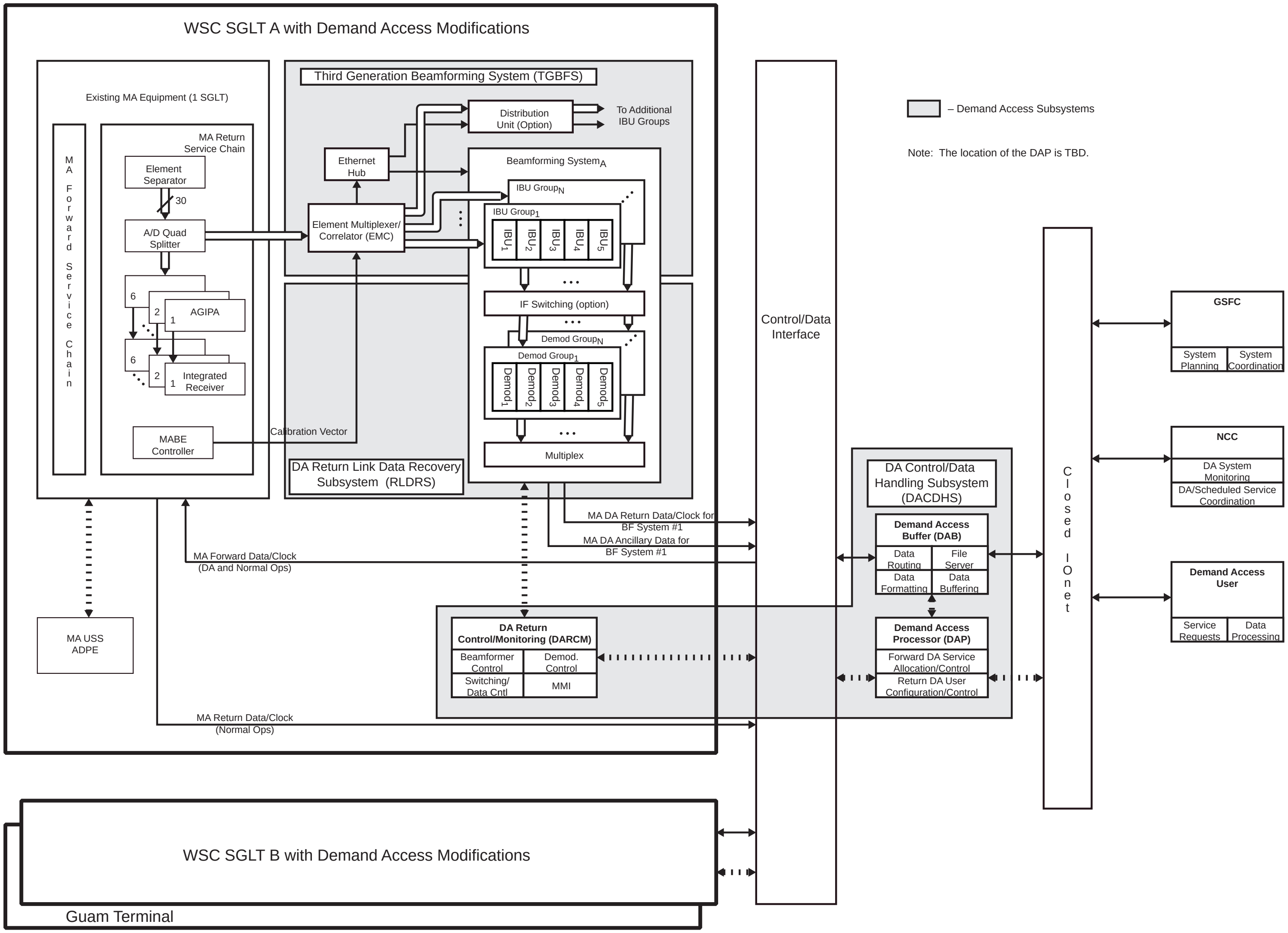

Figure 3-1: DAS Functional Architecture

The DARCM function controls the return service DAS SGLT equipment configuration. This function configures the beamforming and demodulation functions according to the demands of the DAS return service requests. The DAS return service requests are sent to the DAP from the DA user's POCC. The DAP determines the spatial and temporal constraints associated with a request and sends the specifications to the DARCM function to be translated into return service equipment configuration commands. The DAP configures the DAB function to manage the buffering and routing of forward and return service commands and data between the UPs to the associated user POCCs. The Closed NASCOM IP Operational Network[6] (IOnet) is used to transfer service request information, commands, and data between the DAS User and the DAP and DAB functions.

The DAP performs the navigation computations needed to assign the forward and return services. UP and TDRSS spacecraft position information is maintained by the DAP via the propagation of satellite state vectors supplied to the DAP on a regular basis by the FDF. A detailed description of the functions discussed in this section appears in Section 3.4.

3.2 DAS Services

Two one-way communications services are defined for the DAS. These are the one-way DA Forward (DAF) and one-way DA Return (DAR) services. The DAF allows commands and data to be sent from the user POCC to the UP. The DAR service allows the user POCC to receive data sent from the UP. The DAF and DAR services are the elementary building blocks from which more complicated DA user operations scenarios are made. For example, the DAS user can construct combined forward and return services (two-way). The DA user can schedule the one-way DAF and DAR services in the following ways (depending on the user's mission operations objectives):

- separately
- with overlapping time windows, or
- simultaneously.

3.2.1.1 DAF Service

The DAF service is essentially a MAF forward service that has been appropriated through the DAS allocation process. ***The entire DAF service appears to the NCC as a single user that makes frequent requests during periods when MAF services do not appear on the active schedule.***

In the current TDRSS MA operations, the NCC scheduling culminates over a period of several weeks of planning with an active schedule that covers the appropriation of TDRSS resources over the current week. As shown in Figure 3-2, part of the active schedule contains the MAF time slots that have been allotted to the TDRSS users. The remaining unused MAF time slots comprise MAF TDRSS Unused Time (TUT). Each day, the NCC assesses the amount of TUT that is available for the next ten days and broadcasts the TUT schedule via the Internet to TDRSS users. The MAF TUT becomes the DAF scheduling opportunities and is the time available for

[6] NASA Communications (NASCOM) Internet Protocol (IP) Transition Operations Concept Document, GSFC 541-230, September 1996.

scheduling DAF services for DAF users. This time is allotted to DAS users in intervals that are no larger than the interval of time separating two consecutive MAF time slots on the active schedule.

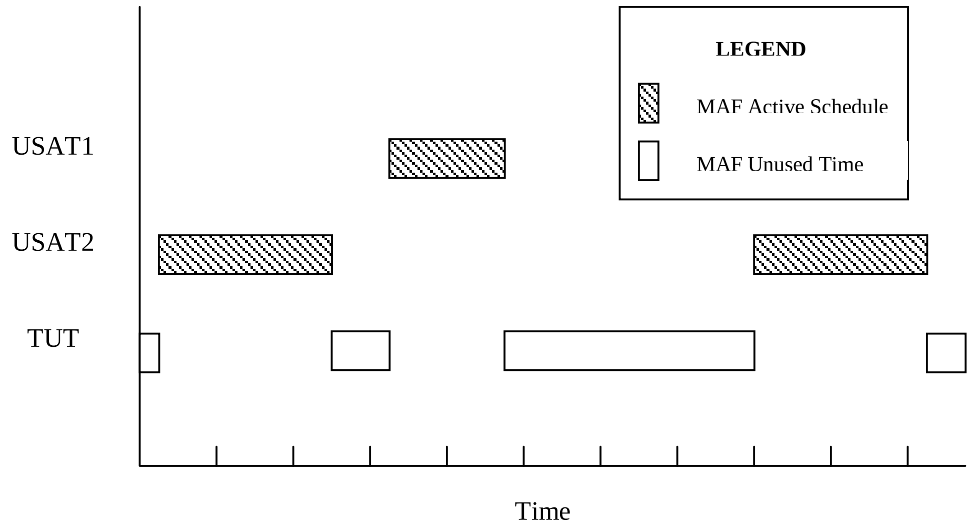

Figure 3-2: NCC Active TDRSS MAF Schedule and TDRSS MAF Unused Time

In order to establish a DAF service, the user POCC must request the time (from the MAF TUT options). Users are guided through the selection process by means of the DA Planning Tool located at the user POCC that interfaces with the DAP. After a suitable range of MAF times are identified, the DAS user requests the DAP to establish the DAF service. DAF services are allocated on a first come, first served basis for DAS users.

The DAF service requires the use of existing GT MAF equipment. Since the NCC controls the GT MAF resources, DAS user requests for the DAF services are automatically coordinated through the NCC. Requests, similar to Scheduling Orders (SHOs), are sent from the DAP to the NCC in order to configure the GT equipment chain to support the DAP requested DAF service. The NCC in turn sends a SHO to configure the MAF at the GT so that the DAF service is available.

Once the DAF service is established, user commands and data can be sent directly to the DAB for formatting and immediate uplinking to the UP. The DAS user may choose to have the command data buffered at the DAB for a delayed uplinking at a specified time after the DAF service begins. Figure 3-3 summarizes the basic steps associated with establishing a DAF service.

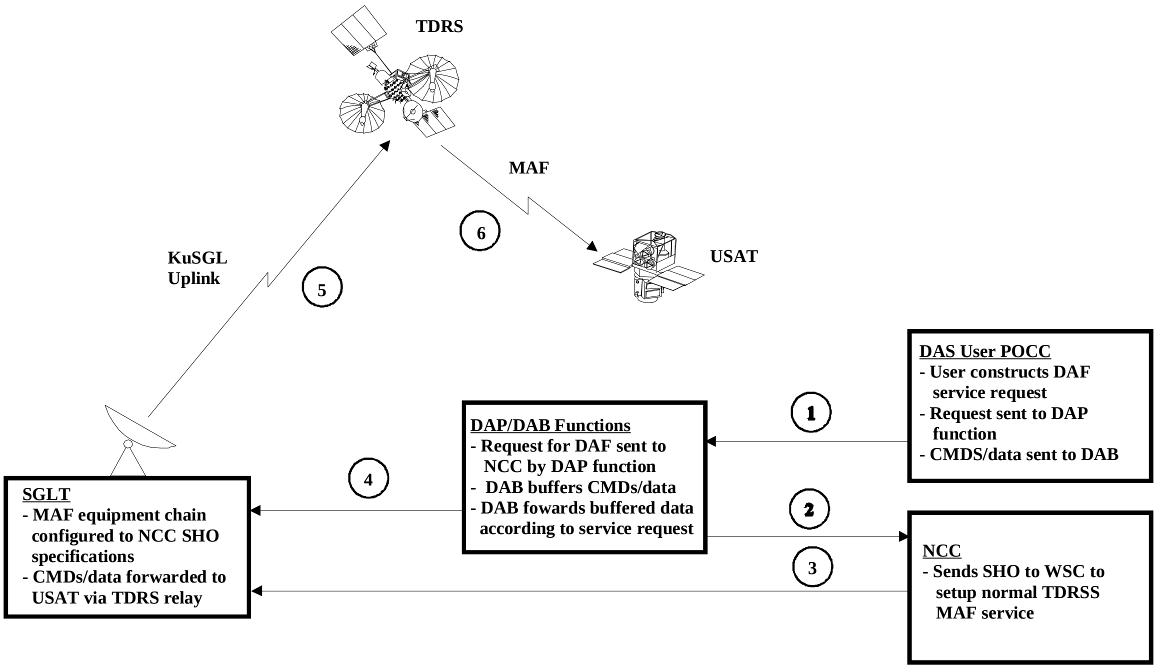

Figure 3-3: Steps Required to Establish a DAF Service

3.2.1.2 DAR Service

The DAR service is more flexible than the DAF service because many DAR users can be simultaneously serviced via an expanded suite of ground-beamforming and demodulation equipment. The upper limit on the number of DAR users is determined by the number of DA beamformers and demodulators present in the SGLT. Increasing the number of beamformers and demodulators in the TGBFS and DA RLDRS, respectively, increases the size of the equipment pool from which service equipment chains can be constructed for simultaneous DAR users. In general, there are two categories of DAR equipment:

- dedicated equipment consisting of beamformers and demodulators owned by specific DAS users, and
- equipment consisting of a pool of NASA supplied beamformers and demodulators that are shared by DAS users.

The DAR service requires the use of some existing MAR and new DAS GT equipment. The DAP chooses DAS beamforming and demodulator equipment if the option arises to use new or existing equipment. If the existing equipment is chosen in place of DAS resources, the scheduling of the equipment occurs through NCC and is transparent to the DAS user. Figure 3-4 summarizes the basic steps associated with establishing a DAR service.

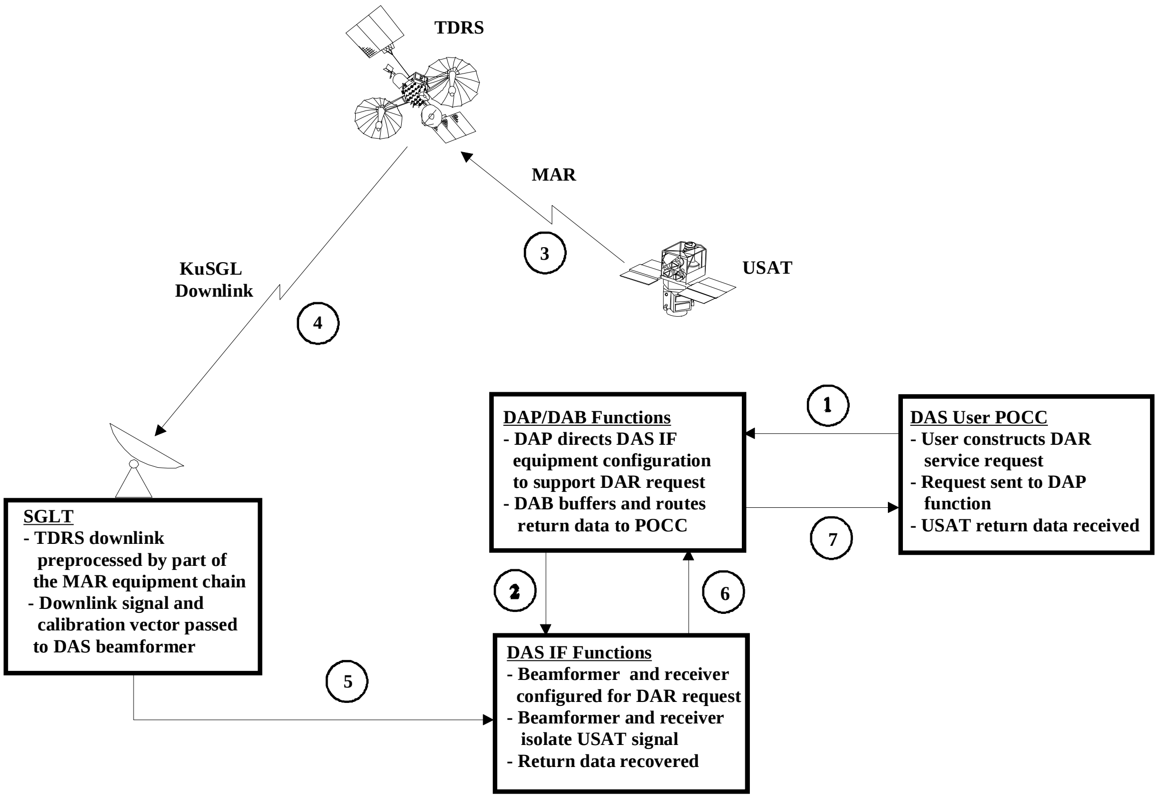

Figure 3-4: Steps Required to Establish a DAR Service

3.3 DA Service Characteristics

3.3.1 DAF Service Characteristics

The characteristics associated with the DAF service are as follows:

- The DAS decides which TDRS will be used for most service requests
- Service times can be selected by the DAS for DAS users with flexible service requirements
- Each individual DAF service duration is limited by the length of the MAF TUT intervals in the NCC active schedule
- There are only two DAF user priorities, normal and emergency
- Under normal operating conditions, DAF services are allocated on a first come, first served basis
- The DAP places emergency DAF service requests at the beginning of the service request queue (the emergency priority will occur infrequently)
- DAF services cannot be allocated continuously. The maximum duration of a DAF service is the length of an unused MAF time interval
- DAF handover can be scheduled by the DAS user as a series of consecutive DAF requests spanning two or more different TDRS visibility time windows.

3.3.2 DAR Service Characteristics

The characteristics associated with the DAR service are as follows:

- DAS users may choose to install their own dedicated DAR beamforming and demodulator equipment.
- Dedicated DAR beamforming and demodulator equipment can be serviced by NASA with a specially arranged maintenance agreement.
- If DAS users do not choose to provide their own beamforming and demodulator equipment, then the DAP will choose the best available set of TDRSS dedicated equipment for the user service. In heavy loading scenarios, this could result in scheduling delays.
- DAS users can route their own data independent of the DAB.

3.4 DA Functions in Detail

This section provides greater detail in the description of the functions discussed briefly in Section 3.1. The elements of the DAS consist of the existing functions of the TDRSS MA services and the new DA functions that will be added to support DA operations. The following functions support the DAS operations capabilities:

- DAF Service Function
- DAR Service Function
- DA Planning Tool Function.

These functions are described in detail in the following sections.

3.4.1 DAF Service Function

Implementation of DAF service is based on the addition of a DA forward link control/data handling function that includes the following DA functions:

- DAP Function
- DAB Function.

The role of these functions in the DAF service function is described in the following sections.

3.4.1.1 DAP Function

The forward link DAP function provides the primary control interface between the WSC DA services and the DA users, the NCC, and Goddard Space Flight Center (GSFC). The DAP implements both forward and return link DA service control in order to minimize user interfaces. Key functions of the DAP supporting forward link DA service include:

- Receipt of TUT messages. This information permits the sharing of scheduled and DA service on a single SGLT by allowing the DAP to avoid requesting DA service during previously scheduled service intervals
- Receipt and acknowledgment of DA user requests for forward link DA service and user configuration messages necessary to control DA service
- Calculation of user spacecraft visibility intervals and determination of user spacecraft to TDRSS spacecraft line of sight for omni-directional antenna service
- Selection of an appropriate TDRSS spacecraft for service
- DAS users can provide their own visibility constraints
- Service setup. Initially, the DAP will set up service by transmitting service requests to the NCC. As an option, the DAP may later be upgraded to have direct access to WSC for service setup
- Status reporting to the user, NCC, and GSFC.

3.4.1.2 DAB Function

The DAB supports the following DAF service data handling functions:

- Acceptance of forward link DA data from DA users
- Forward link DA data buffering. On the forward link, user data may either be passed through the DAB in real time at the time of service initiation or stored within the DAB prior to service initiation
- Return data link buffering. If the user is lost or the user decides to go off-line during DAR operations, data will be buffered by the DAB function
- Formatting and routing of return link data.

3.4.2 DAR Service Function

The DAR implementation (software augmentation to the current WSC and Guam SGLT infrastructures) requires development and deployment of new hardware. Because the implementation benefits different types of users, and TDRSS MAR service allows concurrent multiple users, return DA will accommodate a large number of users with a high level of satisfaction. Depending on the number of users, each user may be provided continuous service via a dedicated, rather than demand access service.

The TDRSS MAR antenna beam can be used (at the discretion of the user) in one of two ways[7]:

1. TDRSS MAR antenna beams track user spacecraft, thus providing the opportunity for user spacecraft to return data any time they are in view of a TDRS. If three widely spaced TDRSs are used, continuous coverage can be provided. A key requirement for this approach is that enough beamformers and demodulators be available at WSC to serve all DA users. Since WSC equipment chains are dedicated to each TDRSS spacecraft, the possibility of an uneven distribution of users in view to a specific TDRSS spacecraft means that the total number of required beamformers and demodulators exceeds the number of users.

[7] In both scenarios, each user is assigned a unique PN code that would be demodulated by a bank of demodulators.

2. A set of stationary MAR beams to support stationary users (e.g., ocean buoys) cover specific regions within the field-of-view of a TDRSS spacecraft. A set of demodulators is provided for each beam with each demodulator matched to a user-unique code. As in the first (tracking) scenario, full random access transmissions by TDRSS users are supported; however, because the users are fixed, no beam adjustments need to be implemented since different users are serviced within the same beam. This approach to sharing a single MA antenna beam among multiple users can provide TDRSS service to non-space users at minimal impact to the existing TDRSS infrastructure.

Overall, the increased operational flexibility and reduction in scheduling costs is expected to reduce the long term mission operations costs of the majority of users of the TDRSS DA service. The key elements/functions (refer to Figure 3-1) of the DAR architecture defined below are:

- TGBFS Function
- RLDRS Function
- DA Control/Data Handling System (DACDHS) Function.

3.4.2.1 TGBFS Function

The TGBFS implements DA MAR link beamforming under control of the DARCM function. The TGBFS interfaces with the existing WSC beamforming equipment of a single SGLT and permits generation of a large number of MAR link antenna beams. Key functions of the TGBFS include:

- Acceptance of digital data from the existing MA Beamforming Equipment (MABE) and distribution of that data to a number of Independent Beamformer Units (IBUs)
- The baseline TGBFS provides sufficient data distribution capacity to support 15 IBU Groups (consisting of six IBUs each) per SGLT. As an option, the TGBFS could include an additional Distribution Unit(s) to regenerate copies of the distributed data to support more beamformers
- Acceptance of ancillary MABE data needed for beamforming and distribution to the IBUs. Such data includes the MABE generated calibration vector
- MAR link beamforming under control of the DARCM function. The Control function sets distinct TDRSS-to-user direction cosines and beamforming modes for each IBU. Output from each IBU is an intermediate frequency (IF) waveform in Digital and Analog format that is ultimately passed to a DA demodulator
- Generation of status data that is passed to the DARCM function.

3.4.2.2 RLDRS Function

The RLDRS consists of those elements needed to recover the MAR link data after beamforming. The subsystem accepts the IF output from the beamformers, performs IF switching (option), signal demodulation, and data multiplexing prior to sending the data to the DA data handling system. Each of these functions is discussed in somewhat more detail below.

<u>IF Switching Function (option)</u>

An IF switching function is an option in the DAR link implementation. The IF switching function permits limited changes to the mapping between IBUs and DA Demodulators. In particular, if an entire IBU Group should fail, the IF switching function will permit re-mapping of IBUs within another IBU Group to the original set of DA demodulators. Such a function may be desired if user unique demodulators are provided.

<u>DA Demodulator Function</u>

The DA demodulators accept the IF signal generated by the IBUs and demodulate the user data contained within. Key functions supported by the DA demodulators include:

- Demodulation of MAR link signals
- Measurement of MAR link Doppler signal in support of DA Doppler tracking (option)
- Acceptance of control information from and passing of status information to, the DARCM function.

<u>Return Link DA Data Multiplexing Function</u>

The DA data multiplexing function receives data from each of the NASA controlled DA demodulators connected to a single SGLT and multiplexes the data for transmission to the DAB for further processing.

3.4.2.3 DACDHS Function

This function provides control to the Return link DA system and supports return link DA data handling. Provided functional elements include:

<u>DAP Function</u>

The Demand Access Processor provides the primary control interface between the WSC DA services and the DA customers, NCC, and GSFC. The DAP implements both forward and return link DA service control in order to provide a minimum number of interfaces to the user
Return link functions provided by the DAP include:

- Receipt of user DA return service control messages including service parameters and data handling instructions (e.g., real time return vs. data buffering)
- High level control messaging to/from the return DA equipment via NCC
- High level control of the Demand Access Buffer in order to configure DA return link data handling
- Return DA status reporting to the DA customer, GSFC, and NCC.

DAB Function

The DAB function supports data handling for both forward and return link DA services. DA return link functions supported by the DAB include:

- Formatting/routing of DA return link data to DA customers. Return link data includes both user spacecraft generated data and (optionally) tracking data messages from the DA demodulators
- Return link DA data buffering. On the return link, customer data may be routed to the customer (via the closed IOnet) in real time or, for users having limited amounts of data, data may be stored for later retrieval by the customer.

DARCM Function

The return link DARCM function implements all control and status monitoring for the return link DA equipment within a single SGLT. This includes:

- Beamformer control: Setting/monitoring beamforming mode, sending direction cosines to each IBU, and monitoring beamformer status
- DA demodulator control: Setting demodulator configuration and monitoring demodulator status
- IF switching and control of the data handling operations
- Additionally, the DA control function provides a local WSC man machine interface that permits complete operation of the WSC demand access equipment (including the DAP and DAB) from the WSC. Each implementation of the DAS SGLT will contain an MMI that will be used to control the DAS equipment located at the SGLT. The DAS Operator at a given SGLT will be able to test the DAS equipment at that site without impacting operations at other DAS based SGLTs. The MMI at one WSC SGLT will be the Master Control Console for initiating start up, configuration, test and termination operations for the DAS equipment at all DAS SGLT installations.

3.4.3 DA Planning Tool Function

The DA Planning Tool Function resides in the DA users operations center. The Planning Tool has the following two functions:

- to provide the DAS user with information to make decisions about DA service availability, and
- to provide a means of placing a DA service request into the DAS.

The tool is capable of requesting and displaying data supplied from a scheduling database located in the DAP. The DAP maintains and constantly updates the database using USAT state vectors supplied by the FDF and TUT schedules supplied by the FDF. In addition to visibility and timeline information, the DAP maintains within the database the resource assignments made for establishing services that were requested by DAS users and accepted by the DAP. The responsibility for managing of the pool of DAS resources lies with the DAP. The information in database is accessed by the Planning Tool to present the DAS user with an accurate perspective with respect to DAS scheduling time and resources. The Planning Tool is used to construct a request once the assessment of the information provided to the DAS user is completed.

4. DA OPERATIONS

This section provides scenarios for the DA user and background operations categories. The scenarios are based on the DA services that are presented in Section 3.2. A scenario consists of the sequence of messages that flow in the DAS in order to meet the objective of providing the DAS user with the capabilities of sending commands or data to a UP and receiving data from the UP. Both the DAF and DAR services and the overhead message transactions required to attain the communications objectives associated with each scenario are presented in the following sections.

The scenario operations hierarchy for DA is shown in Figure 4-1. The two categories of operations shown in the hierarchy are DA User and DA Background Operations. DA User Operations are initiated by the POCCs and are used to plan, establish, and reconfigure DA services. DA Background Operations are transparent to the DA user. They perform the tasks needed to maintain the DAS.

Planning Operations is an activity that is common to the other members of the DA User Operations category. Planning precedes requests for services and the reconfiguration of an existing DA service. As such, it is shown as a separate operation that is undertaken prior to the execution of the remaining operations in the DA User Operations category.

The DA operations details presented in the following sections are represented in terms of message flow sequences that are listed in a table. The function of the table is to depict in sequence of occurrence the messages that are exchanged between the processor nodes of the DAS during an operation. The pertinent DAS and SN processing nodes are labeled along the top columns of table. Each row in the table represents a message exchange between a source processor node and a destination processor node. The source processor node that initiates the message flow in a given row is designated by an “S” in the column that designates that processor. The destination processor node for the message flow is designated by a “D” in the column that corresponds to the processor that receives the message in the same row. A message may be broadcast simultaneously to more than one destination. This is represented by more than one “D” appearing in the same row of the table. A comment column is available to describe the essence of the message exchange in the row entry. Table 4-1 illustrates the message flow sequence concept described above.

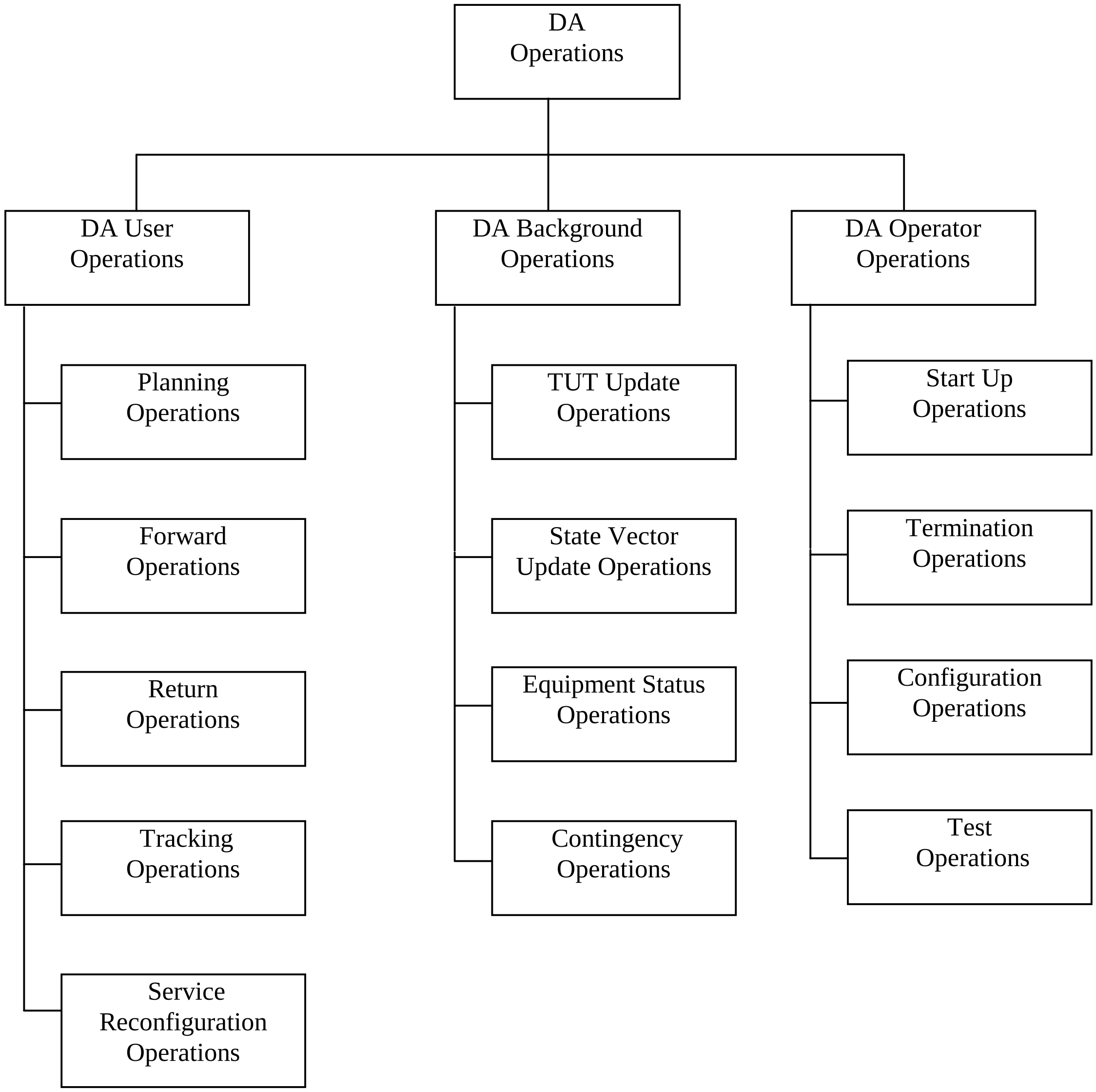

Figure 4-1: DA Operations Hierarchy

Table 4-1: Example of an Operations Message Flow Sequence Segment

Step	POCC	DAB	USAT	Comments
N	S	D		User command data is sent to the DAB for buffering with uplink transmission time
N + 1		S	D	Commands are transferred at the designated time from the DAB to the USAT via the SN

4.1 DA User Operations

4.1.1 Planning Operations

This section is divided into the following two parts:

- User Planning Operations
- System Planning Operations.

The first part describes the planning operations from the perspective of the DAS user working with the Planning Tool that is running on a processor at the POCC. The second part describes operations of the DAS from the perspective of DAS operations that maintain the database used by the Planning Tool to provide the DAS user with decision making information. The planning sessions are intimately related to the service requests that follow the session since the requests are derived from the information presented to the DAS user through the Planning Tool. The Planning Tool is used by the POCC to place each request into the DAS.

4.1.1.1 User Planning Operations

Each user DA service request will be preceded by a planning session that provides the user POCC with the information needed to decide how to setup the request within the context of the available DA service time and the service request objectives. The DAS user interacts with the Planning Tool's Graphics User Interface (GUI) during the planning session phase. At the most basic level of operations, the user is presented with the time slots that remain available on the TUT schedule which is updated daily by the NCC. The user can vary the level of flexibility of the scheduling requests derived from this information from a completely flexible to highly specific request for DAS services. The amount of complexity associated with the request depends in general upon its flexibility. Examples of the simple requests that don't burden the user from a planning perspective are as follows:

- The DAS user accepts any available TUT slots for the purpose of uploading buffered commands and data to the UP. In this situation the user provides commands and data for buffering but leaves it to the DAS to decide when the DAF service will be established to upload the information to the UP
- A DAS user with dedicated DAR equipment requests that a dedicated service be setup on a continuous basis to relay UP data to the user POCC.

The Planning Tool can retain information that characterizes the routine operations of a DAS user. This information becomes a customized user service profile. The profile allows the user to set up requests rapidly while concentrating only on the parameters that change from each instantiation of the service request to the next. The configuration profile significantly reduces the amount of user/Planning Tool interactions for requests that reoccur frequently in the DAS user's operations repertoire.

Since DAS services are provided on a first come, first served basis, the TUT will be in a continual state of reduction as DAS users are allotted time. As such, scheduling may require that more than one iteration of the planning sequence be performed during heavy DA user loading periods before a resulting request is accepted by the DAP. Iterative planning sessions are expected to occur

- infrequently for the MAF services and
- almost never for the MAR services.

4.1.1.2 System Planning Operations

From the system perspective, the DAP processor automatically updates the DAS database as updated spacecraft state vectors and TUT schedules are supplied from the FDF and NCC, respectively. These activities are background operations that are described in later sections. The planning session will consist of message transactions between the POCC and the DAP. Table 4-2 shows the message flows that occur during planning operations.

Table 4-2: Planning Operations Message Flow Sequence

Step	POCC	DAP	Comments
1	S	D	DA request made for planning information
2	D	S	Planning information in Planning Tool format extracted from the DAP database

Upon receipt of the planning information, the Planning Tool is used to determine how the available time can be used to meet the DA scheduling objectives of the user. Once a strategy has been developed, the POCC can then request a service that falls within the constraints of the DA scheduling timeline. The service request phase that terminates the planning session phase is not shown in Table 4-2 but it is included as part of the description of the DAS user initiated operations in the following sections.

4.1.2 Forward Operations

DAF operations provide the DA user with a one-way open data communications channel from the user POCC to the USAT. Two modes of operations exist for DAF operations. These modes are:

- Instantaneous Command Mode – DAB passes through commands from the user POCC for uplink to the UP in real-time
- Delayed Command Mode – DAB buffers the commands provided by the user POCC for uplinking to the UP at a user specified time.

Table 4-3 shows the sequence of messages that flow throughout the actions of requesting, activating, using, and terminating the service.

Table 4-3: DAF Operations Message Flow Sequence

Step	POCC	NCC	DAP	DAB	GT	UP	Comments
1	S		D				DAF operations request with start and stop times, message uplink time
2	D		S				Request accepted by the DAS
3		D	S				SHO-like message requesting configuration of existing MAF equipment
4	S		D				Notification of service to start
5		S	D				Acknowledgment of forward service implementation
6		S			D		Forward equipment chain configuration message
7	D		S				Service in progress notice(s)
8	S			D			Data formatting
9				S	D		Formatted commands forwarded to GT for uplinking to UP immediately or after a delay depending on the operations mode
10					S	D	Commands uplinked to UP via TDRS
11	D		S				Notification of pending service stop
12			S	D	D		Broadcast service termination message
13	D		S				Notification of service termination

4.1.3 Return Operations

DAR operations can be subdivided into the three categories shown in Figure 4-2. The return scenarios provide the DAS user with a number of options to collect data from the UP. The choice of scenario depends upon the following:

- operational characteristics of the user's mission
- available budget, and
- maintenance operations.

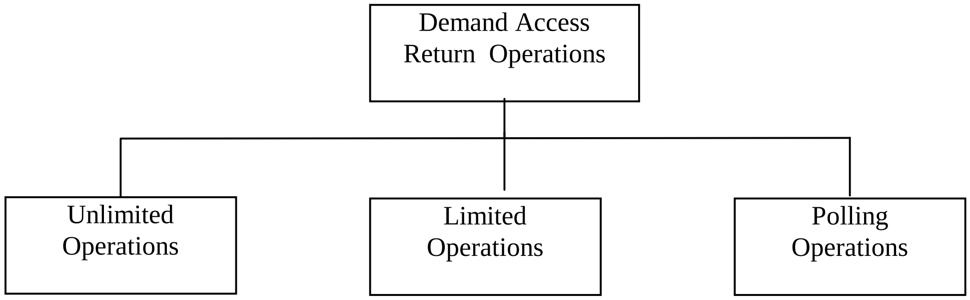

Figure 4-2: DAR Operations Hierarchy

4.1.3.1 Unlimited Operations

The objective of the DAR Unlimited Operations is to provide the user with the capability of receiving data from it's UP on a continuous basis as long as the platform is in view of a TDRS. Unlimited Operations support several operations modes. These modes are as follows:

- Single UP Mode – Users that require long periods of time to return data from a single UP (balloon, aircraft, buoy, etc.) can use this unlimited DAR service scenario option provided that their DAR equipment and UPs meet the following constraints:
  - UP has a dedicated beamformer and demodulator at one GT
  - UP is in constant view of at least one TDRSS spacecraft
- Multiple UP Mode – Users that require long periods of time to return data from multiple UPs (balloons, aircraft, buoys, etc.) can use this unlimited DAR service scenario option provided that their DAR equipment and UPs meet the following constraints:
  - UPs have a dedicated beamformer and multiple demodulators
  - UPs are in constant view of one TDRSS spacecraft
- UP Handover Mode – Users with dedicated DAS equipment can schedule continuous MAR service support for USATs as these platforms circle the Earth provided that their DAR equipment and UPs meet the following constraints:
  - UPs have dedicated beamformers and demodulators at more than one SLGT (all SLGTs for a full orbit or more of continuous data return)
  - UP is in constant view of at least one TDRSS spacecraft.

Table 4-4 shows the message flow associated with the execution of this scenario. In order to terminate this operation, the DA user must use the termination mode of the DA Service Reconfiguration Operation described below. The shaded rows in Table 4-4 refers to a precursor activity that occurs at outset of the initial service request.

Table 4-4: DAR Unlimited Operations Message Flow Sequence

Step	POCC	DAP	DAB	DARCM	RLDRS	TGBFS	GT	UP	Comments
1	S	D							Unlimited DAR service request with start, PN code(s), and beam forming specifications
2	D	S							Request accepted by DAP
3	D	S							Service to start notice
4		S	D						Set up buffering and routing for return data
5		S		D					DARCM commanded to setup RLDRS and TGBFS equipment
6				S	D	D			DAS equipment configuration
7	D	S							Service in progress notice(s)
8							D	S	UP sends signal/message to GT
9						D	S		GT sends signal/message to beamformer
10					D	S			Signal demodulated
11			D		S				Message data buffering
12	D		S						Return data routing to POCC
13	D		S						Return data delivery

4.1.3.2 Limited Operations

The objective of the DAR Limited Operations is to provide DA users with the capability of scheduling limited amounts of predetermined return service time. These DA service contact opportunities are scheduled with known start and stop times. This operational scenario provides the DA users with a simple and cost effective means of scheduling return service time windows for routine data return collection activities such as data dumps, etc. Table 4-5 shows the message flow sequence that characterizes the Limited DAR Operations. It is the DAS user’s responsibility to ensure that the Limited DAR service coincides with the time that the UP will transmit the return data.

Table 4-5: DAR Limited Operations Message Flow Sequence

Step	POCC	NCC	DAP	DAB	DARCM	RLDRS	TGBFS	GT	UP	Comments
1	S		D							Limited DAR service request with start, stop times, PN code, and beam forming specifications
2	D		S							Request accepted by DAP
3	D		S							Service to start message
4		D	S							If existing MAR equipment is to be selected, send SHO-like message
5		S						D		If existing MAR equipment has been selected, use existing equipment chain configuration
6			S		D					If DAS equipment is selected, DARCM commanded to setup RLDRS and TGBFS equipment
7					S	D	D			If DAS equipment is selected, RLDRS and TGBFS equipment configuration
8			S	D						If DAS equipment is selected, configure DAB for data buffering, formatting, and routing
9	D		S							Service in progress notice(s)
10								D	S	UP sends signal/message to GT
11							D	S		GT sends signal/message to beamformer
12						D	S			Signal demodulated
13				D		S				Message data buffering
14	D			S						Return data routing to POCC
15	D		S							Notification of pending service stop
16			S	D	D					Broadcast terminate service command
17					S	D				Cancel reserved demodulator
18					S		D			Cancel beam if not being used by other users
19		S						D		Cancel return NCC service if not being used by other users
20	D		S							Service termination notice

4.1.3.3 Polling DAR Operations

This section is divided into two parts. The first part is an introduction to the concept of polling and the second part contains an illustration of the sequence of message flows associated with the implementation of the polling concept.

4.1.3.3.1 Introduction to Polling Concept

Polling is the sequential servicing of multiple UPs in the DAR service. This class of service is suitable for users who do not own, or wish to share, many sets of beamforming equipment. Essentially, one[8] set of DAR equipment[9] is periodically reconfigured so as to form an antenna beam on one of several UPs. For global coverage, it will be necessary to have two sets (one set per SGLT) of beamforming equipment: one in Guam, the other in White Sands, NM (i.e., WSC).

The beamformer and the acquisition time of the demodulator dictate the maximum polling update rate. Currently, the TGBFS beamformer will allow for one-second updates, and a typical demodulator will take a few seconds to acquire a signal. In practice, the polling rate will likely be smaller, and will, in any event, be user defined.

The following paragraphs contain a representative polling scenario in which one set of beamforming equipment is used to service five user satellites. For simplicity, the satellites are assumed to be covered by a single TDRS, which is serviced by WSC. In this scenario, we assume an emergency type of service. When a user spacecraft encounters a fault situation,[10] it emits a continuous beacon using an omni-directional antenna. The DA resources available in this scenario are:

- One dedicated beamformer at WSC, and
- One dedicated demodulator at WSC.

The user POCC uses the planning tool to schedule a polled DAR service. The DAP accepts and processes this service request[11]. This particular user requests a polling time of 20 seconds. Each user satellite transmits a unique PN code[12].

The DAP, having knowledge of TDRS and user satellite state vectors, will sequentially commutate between the five user spacecraft by calculating the direction cosines required for polling in real time. The polling time line is summarized in Table 4-6 starting at 10:00:00 UTC. The DAP sends each direction cosine to the DAR controller. The controller passes each direction cosine to the beamformer at the proper time so as to facilitate the polling process.

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[8] It is certainly possible to do polling with greater than one set of beamforming equipment. One set is assumed here for simplicity.
[9] The equipment essentially consists of a beamformer and a demodulator.
[10] The user spacecraft fails in some serious capacity, and requires reconfiguration from the ground.
[11] The word "request" is misleading since the service is guaranteed.
[12] This need not be the case in general.

Table 4-6: Partial Polling Timeline for Representative Scenario

Time (UTC)	UP Serviced
10:00:00	1
10:00:20	2
10:00:40	3
10:01:00	4
10:01:20	5
10:01:40	1

In the event that a user satellite beacon is detected, the polling process stops, and the DA service is now dedicated to that particular user satellite. The signal detection event is handled in the following way:

1. The dedicated demodulator locks onto the beacon signal.
2. This locked status is sent to the demodulator controller.
3. The demodulator controller notifies the DAP.
4. The DAP ends the polling, but continues dedicated service to the detected user satellite.
5. The DAP notifies the user POCC that it has detected a beacon from satellite "n".
6. The POCC begins receiving beacon data via the DAB.
7. At this point, the user POCC may request DAF service to reconfigure that particular user satellite.

Clearly, there are many polling scenarios. For example, if the user desires a high level of confidence, the polling process could continue even after a beacon is detected. A second set of DAR equipment could be requested to dwell on the detected satellite beacon. By doing this, the user would be assured that multiple satellite failures could be detected.

4.1.3.3.2 Polling Operations

The objective of the Polling DAR Operations is to provide single DA users with the capability of scanning a set of USATs controlled by the user POCC and locking onto USAT MAR signals that are encountered in the polling scenario. As indicated in the previous section, a variety of polling scenarios is possible. Therefore, only a representative operations overview is presented here. Table 4-7 shows the message flow sequence that characterizes the polling DAR operations described in the previous section. The DA Service Reconfiguration Operations (SRO) described below can be used to terminate this sequence.

Table 4-7: Polling DAR Operations Message Flow Sequence

Step	POCC	DAP	DAB	DARCM	RLDRS	TGBFS	GT	USAT	Comments
1	S	D							Polling DAR service request with start, polling rate, special dwell time constraints, and PN codes and IDs for UPs
2	D	S							Request accepted by DAP
3	D	S							Service to start message
4				S	D	D			RLDRS and TGBFS equipment configuration with beamforming information for each UP (constantly changes with UP motion)
5		S		D					DARCM commanded to setup DRS equipment for new PN code sequencing
6							D	S	UP sends signal/message to GT
7						D	S		GT sends signal/message to beamformer
8		D			D	S			Check for receiver lock status. If signal is detected, signal is continuously demodulated if PN code match occurs. If signal is not detected return to step 5
9			D		S				Message data buffering and routing
10	D		S						Return data routing to POCC

4.1.4 Tracking Operations

DA tracking operations allow the FDF to schedule one-way Doppler tracking services. One-way DAR tracking scenarios resemble one-way DAR scenarios with the addition of Tracking Data Messages (TDMs) being sent to the FDF. In order to schedule the one-way Doppler return, the DAS user must have a dedicated demodulator with a Doppler extractor in order to make the Doppler measurement. Table 4-8 shows the message flow sequence that characterizes the one-way return Doppler tracking operations.

Two-way Doppler and range tracking services are available as DAS options. DAS requests for either of these services can result in the DAP requesting the NCC to set up the current MA tracking service option. Two-way range will not be supported directly by the DAS equipment. However, a second option exists for two-way Doppler. The two-way Doppler service can be established when the DAS user requests concurrent DA forward and return services while a dedicated demodulator with a Doppler extractor is assigned to the equipment chain.

Table 4-8: One-way Doppler Return Tracking Operations Message Flow Sequence

Step	POCC	FDF	DAP	DAB	DARCM	RLDRS	TGBFS	GT	UP	Comments
1	S		D							Tracking service request with start, stop times, PN code, and beam forming specifications
2	D		S							Request accepted by DAP
3	D		S							Service to start message
4					S	D	D			RLDRS and TGBFS equipment configuration
5	D		S							Service in progress notice(s)
6								D	S	UP sends signal/message to GT
7							D	S		GT sends signal/message to beamformer
8						D	S			Signal demodulated and Doppler extractor makes measurement
9				D		S				TDM generated from Doppler extractor output and sent to the DAB for routing
10		D		S						TDM Return data routing to FDF
11	D		S							Notification of pending service stop
12			S	D	D					Broadcast terminate service command
13					S	D				Cancel demodulator
14					S		D			Cancel beam if not being used by other users
15	D		S							Service termination notice

4.1.5 Service Reconfiguration Operations

The objective of the SRO is to provide both forward and return DAS user with the capability of changing a previously accepted operations request from the queue of scheduled or ongoing scenarios. Typical reconfiguration operations include:

- Cancellation of a previously accepted request
- Termination of an operations scenario currently being executed
- Request for alternative equipment chains
- Change the beamformer mode

Reconfiguration can occur before or during the execution of the existing user's operations request depending upon the nature of the reconfiguration results being sought by the user. Table 4-9 shows the message flow associated with the DA Reconfiguration processing operations.

Table 4-9: Service Reconfiguration Message Flow Sequence

Step	POCC	NCC	DAP	DAB	DARCM	RLDRS	TGBFS	GT	Comments
1	S		D						Request to reconfigure a previously scheduled DAF or DAR service at a specified time
2		D	S						DAF reconfiguration request
3		S						D	DAF reconfiguration command
4			S	D	D				DAR service reconfiguration command broadcast
5					S	D			Reconfigure demodulators as required for DAR
6					S		D		Reconfigure beamforming equipment as required for DAR
7	D		S						Notification of service reconfiguration

4.2 DA Background Operations

Background operations support the overall operations of the DAS and are virtually transparent to DAS users. The background operations scenarios represent DAS overhead operations that support the user scenarios with updated information for scheduling purposes.

Figure 4-3 shows the hierarchy of background operations scenarios present in the DAS. The operational scenarios presented in this section do not account for contingencies that arise due to system faults or other actions that do not pertain directly to the objective of supporting the required information transfer between existing TDRSS and DAS elements.

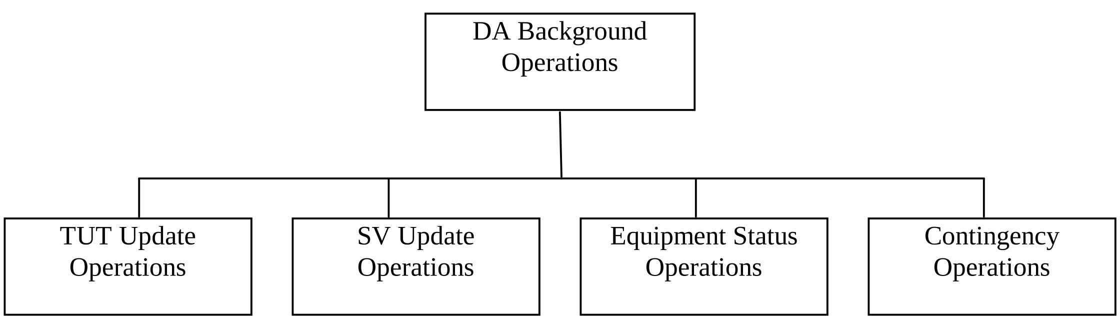

Figure 4-3: DA Background Operations Hierarchy

4.2.1 TUT Update Operations

TUT is determined by the NCC each day when the schedule for a ten-day window (starting on the current day) has been assessed. TUT represents all of the time on the NCC schedule when MAF and MAR services are not scheduled. Once the daily schedule update has been finalized, the NCC sends the DAS the TUT schedule for that ten day window. This message flow is currently implemented as an Internet e-mail transaction. The unscheduled MAF and MAR services become the DAF and DAR time slots that are presented to the DA Planning Tool for DA user scheduling opportunities. Table 4-10 shows the periodic flow of TUT information from the NCC to the DAP.

Table 4-10: TUT Update Message Flow Sequence

Step	NCC	DAP	Comments
1	S	D	Daily TUT schedule update

4.2.2 State Vector (SV) Update Operations

The FDF computes the SVs of the UPs and TDRSS satellites for various purposes. This information will be provided to the DAS as SV updates[13] are available from the FDF. The SV updates will be used by the DAS to calculate the periods of line-of-sight visibility between the user satellites and the TDRSs in order to support DA service schedule planning. Table 4-11 shows the message flow associated with the SV updates.

Table 4-11: SV Update Message Flow Sequence

Step	FDF	DAP	Comments
1	S	D	SV updates

[13] TDRS attitude data may be include in this background operation.

4.2.3 Equipment Status Operations

The DAP constantly monitors the status of the DAS equipment by polling for and collecting status information from each of the DAS subsystems. Table 4-12 shows the message flow associated with this background activity.

Table 4-12: Equipment Status Operations Message Flow Sequence

Step	NCC	DAP	DAB	DARCM	RLDRS	TGBFS	Comments
1		S	D	D			Request for status broadcast by DAP
2				S	D	D	Status request forward to DAR equipment subsystems
3				D		S	TGBS status report
4				D	S		RLDRS status report
5		D		S			DARCM forwards status about itself and its subordinate equipment to the DAP
6		D	S				DAB status forwarded to DAP
7	D	S					Equipment status report

4.2.4 Contingency Operations

The steps presented in the previous Sections as operations message flow tables are high-level representations of the, low-level messages will augment these message flow tables to allow for contingencies, such as non-user initiated DA service cancellations, acknowledgements of messages received, etc. The low-message transactions needed to support a given user objective or system background activity. In reality level messages are not presented here since they are not germane to the understanding of the high-level concepts being presented in this document. Both high and low-level message flows will be presented in a subordinate DA interface design document that accounts for all of the messages that can occur in the implementation of the DAS.

4.3 DAS Operator Operations

DAS Operator Operations are divided into the four categories shown in Figure 4-4. These scenarios provide the Master DAS Operator located at one of the WSC SGLTs with an MMI to start up, configure, terminate, and test the DAS system. The DAS Operators at each of the remaining SLGTs will receive status reports for the DAS equipment via their MMIs.

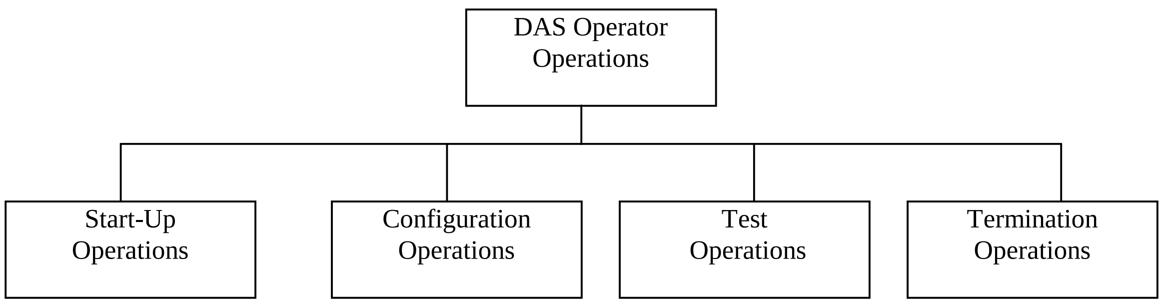

Figure 4-4: DAS Operator Operations Hierarchy

4.3.1 Start-Up Operations

Start-Up Operations provide the Master DAS Operator at a WSC SGLT with the capability of starting the DAS equipment at that SGLT. Table 4-13 shows the high-level message flow sequence that defines the start up operations.

Table 4-13: DAS Start Up Operations Message Flow Sequence

Step	OP	DAP	DAB	DARCM	RLDRS	TGBFS	Comments
1	S	D					DAS Operator initiates start up commands at MMI
2		S	D				DAP commands each DAS function to undergo initialization and the current system configuration file parameters are installed
3		S		D			
4				S	D		
5				S		D	
6				D		S	DAS functions report status at completion of start up sequence
7		D		S			
8				D	S		
9		D		S			
10		D	S				
11	D	S					DAP reports status of system at the end of the system start up

4.3.2 Configuration Operations

DAS Configuration Operations provide the Master DAS Operator with the capability to modify system configuration files to account for equipment added to or removed from the DAS. This allows the system to recognize changes in equipment status (the addition or removal of equipment) that have occurred from the previous start up operations. The DAP automatically distributes system configurations parameters to the equipment that makes use of this information during DAS Start Up Operations. Table 4-14 shows the message sequence that defines the configuration operations.

Table 4-14: DAS Configuration Operations Message Flow Sequence

Step	OP	DAP	DAB	DARCM	RLDRS	TGBFS	Comments
1	S	D					DAS Operator initiates configuration commands at MMI and DAP modifies the Configuration Database
2	D	S					DAP reports status of system at the end of the configuration procedures

4.3.3 Test Operations

Test Operations provide the Master DAS Operator with the capability of testing the DAS equipment at each SGLT. Table 4-15 shows the high-level message flow sequence that defines the test operations.

Table 4-15: DAS Test Operations Message Flow Sequence

Step	OP	DAP	DAB	DARCM	RLDRS	TGBFS	Comments
1	S	D					DAS Opeartor initiates test commands at MMI
2		S	D				DAP commands each DAS function to undergo test procedures
3		S		D			
4				S	D		
5				S		D	
6				D		S	DAS functions report status at end of test sequence
7		D		S			
8				D	S		
9		D		S			
10		D	S				
11	D	S					DAP reports results of the system test

4.3.4 Termination Operations

Termination Operations provide the Master DAS Operator with the capability of shutting down the DAS equipment at that site in an orderly fashion. Table 4-16 shows the high-level message flow sequence that defines the termination operations.

Table 4-16: DAS Termination Operations Message Flow Sequence

Step	OP	DAP	DAB	DARCM	RLDRS	TGBFS	Comments
1	S	D					DAS Opeartor initiates terminate commands at MMI
2		S	D				DAP commands each DAS function to undergo an orderly shutdown
3		S		D			
4				S	D		
5				S		D	
6				D		S	DAS functions report status at end of termination sequence
7		D		S			
8				D	S		
9		D		S			
10		D	S				
11	D	S					DAP reports status of system at the end of the system termination

5. OPERATIONS SCENARIO EXAMPLE

This section contains an example of the DA operations scenario described in the Section 4 from the start of the planning stage through the implementation of the requested service, and the use of the service by the DAS user. The scenario will consist of a POCC in the process of establishing a one-way return service for a limited amount of time from a USAT. In this situation, the DA user will be provided with a beamformer and demodulator from the common DA resources provided by NASA. The user will request a specific time window for the service based on the information provided by the DAS through the DA Planning Tool. The contact time intervals will be chosen to coincide with previously scheduled times that the USAT will transmit data via a DAR. When the service is established, data will be sent from the USAT to the user POCC in the time window defined by the service request. The DAR service is automatically terminated at the end of the user specified time interval. This section is divided into the following five operational stages:

- Planning
- Service Request
- Service Implementation
- User Data Communications, and
- Service Termination.

5.1 Planning Stage

The planning stage consists of the POCC sending a request to the DAP in order to obtain information on the available DAR service intervals. Figure 5-1 shows the message transactions associated with the planning stage. The DAP maintains all of the information about USAT and TDRSS spacecraft visibility intervals. The front-end of the Planning Tool is located at each POCC and a database of DAS resources is maintained at the DAP and is constantly updated based on spacecraft visibility and the user load that is being handled by the DAS at that instant. DAS beamforming and demodulator equipment status is also maintained by the DAP.

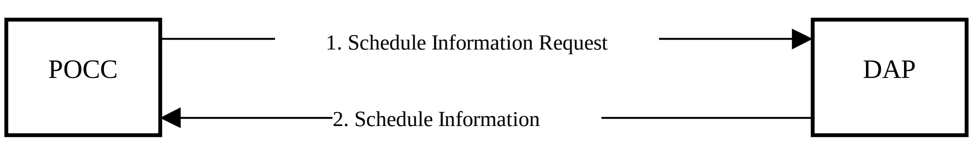

Figure 5-1: Service Request Planning Stage

The content of the messages exchanged between the POCC and DAP are as follows:

1. POCC and USAT IDs, type of DA service being requested, duration of the service, and DAS and TDRSS resource selection constraints to be imposed by the POCC

2. Available time intervals in which the requested service can be established based on visibility and equipment constraints specified in the planning information request.

The planning information received by the POCC from the DAP allows the POCC to see the request scheduling options that are currently available as DAR options that meet the constraints specified by the POCC in the information request. This information is dynamic in the sense that other POCCs may be simultaneously requesting planning information and entering service requests based on the planning information. Since the service requests are honored on a first come, first served basis, the changing availability of resources can occasionally lead to a competition for the resources between POCCs during the service request stage. In these very limited situations, several iterations of planning strategy refinement may be required to adjust to aging information associated with an early snapshot of the DAS resources.

5.2 Service Request Stage

The POCC uses the request planning information described in the previous section to arrive at a service request. The request is sent from the POCC to the DAP where it is assessed in order to determine whether it can be granted based on the status of scheduled resources that are available at the instant the request is received. Figure 5-2 shows the message transactions associated with this stage.

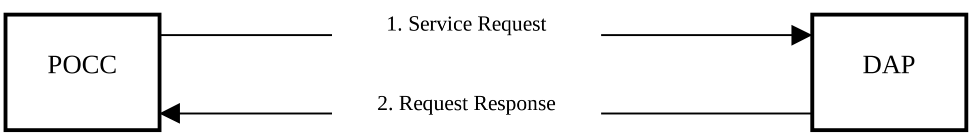

Figure 5-2: Service Request Stage

The content of the messages exchanged between the POCC and DAP are as follows:

1. POCC and USAT IDs, type of DA service being requested, duration of the service, and DAS and TDRSS resource selection constraints

2. Two possible responses from the DAP can occur. These are:

- acknowledgement of the successful scheduling of the request, or
- notification of failure to schedule due to the preemption of the desired resources by another user who has entered a conflicting request after the planning information had been issued to the POCC making the current request.

If a failure to schedule message has been received by the POCC, the POCC must alter its planning strategy to accommodate the change in the resource status of the DAS since the original planning information was received.

5.3 Service Implementation Stage

Assuming that an acknowledgement of the service request being granted has been sent to the POCC, the DAP will reserve the required DAS resources for the time interval specified by the request. Prior to the onset of the implementation of the service, the DAP will notify the POCC that the service is about to start. The DAS controlled resources will then be configured to support the implementation of the service and the POCC will be notified that the service is in progress.

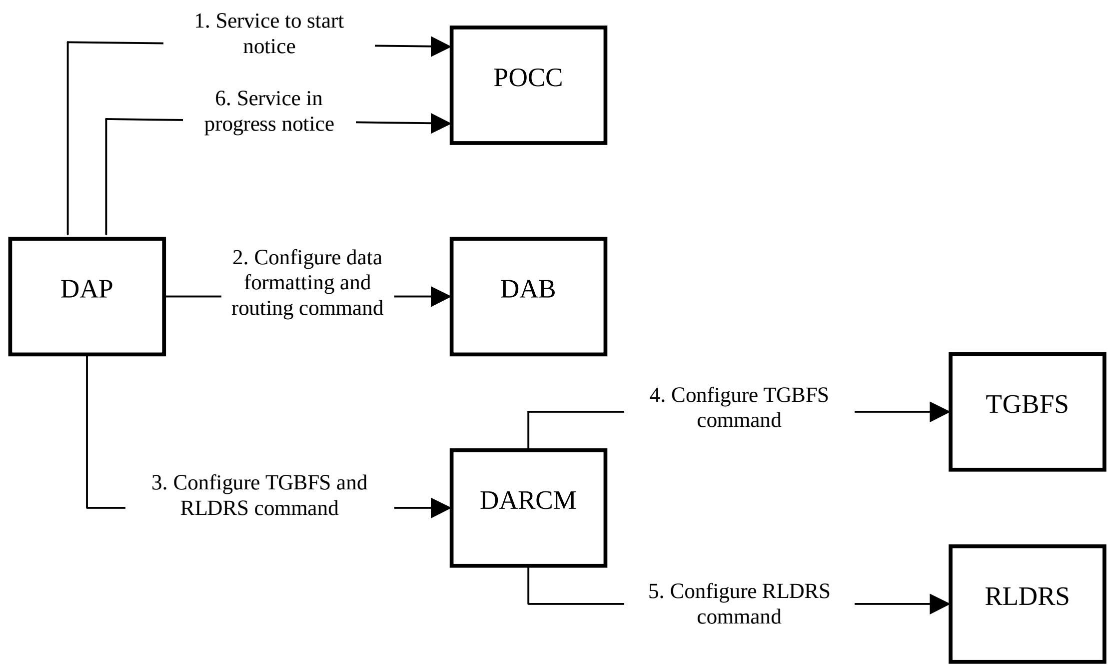

Figure 5-3: Service Implementation Stage

The content of the messages exchanged in Figure 5-3 is as follows:

1. Notification to the POCC that the service requested earlier is about to start.

2. Parameters to establish return data routing through the DAB to the designated POCC when the service starts.

3. Notification to DARCM to configure TGBFS and RLDRS according to the specifications of the service request.

4. PN code for the RLDRS to allow demodulation of the USAT MAR signal.

5. Direction cosines for isolating the USAT signal in the return MAR beam.

6. Notification to the POCC that the requested DAR service is established and is in progress.

5.4 User Data Communications Stage

The user data communications stage consists of pipelining user data from the USAT to the POCC via the TGBFS, the RLDRS, and the DAB. Figure 5-4 shows the flow of MAR signal encoded with the USAT message from the USAT, through the DAS RF front-end equipment, the demodulation processing, and routing to the user POCC.

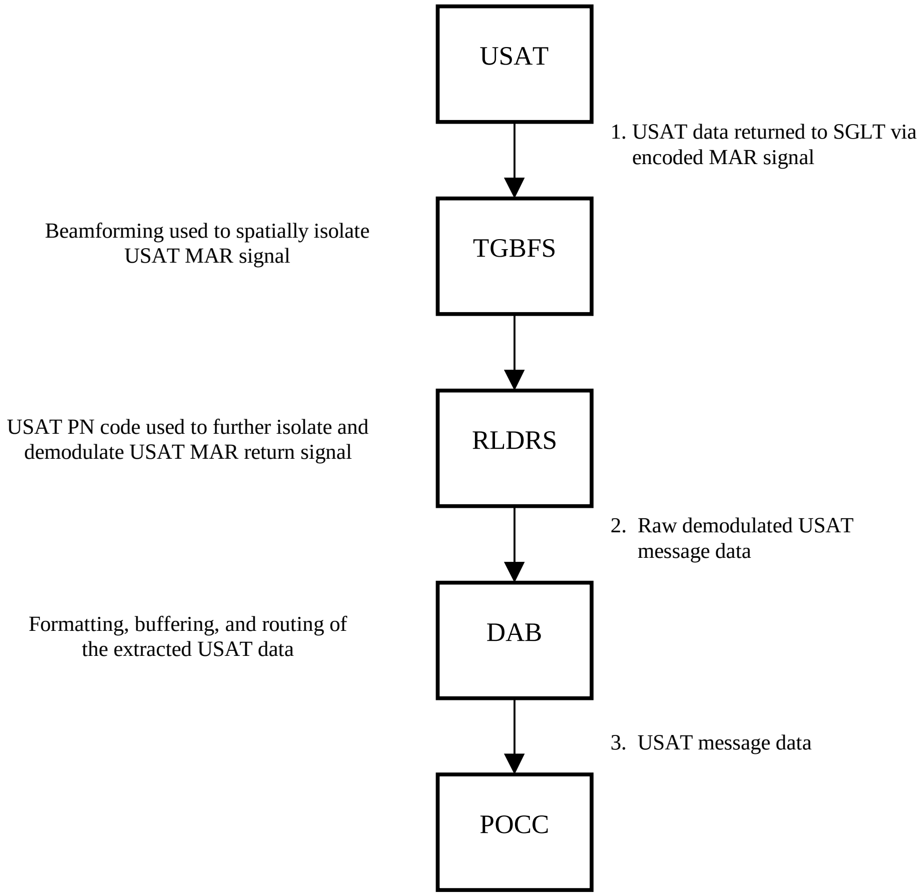

Figure 5-4: User Data Communications Stage

The content of the messages exchanged in Figure 5-4 are as follows:

1. USAT message data encoded on the MAR signal that is sent from the USAT to a TDRSS spacecraft and forwarded to an SGLT.

2. Raw data output from a demodulator in the RLDRS.

3. USAT message data formatted.

5.5 Service Termination Stage

The termination stage consists of an orderly shutdown of the service that is orchestrated by the DAP. Each controller in the DAS that is responsible for establishing and maintaining the service is commanded by the DAP to remove the service from the queue of active services being maintained by the DAS. Figure 5-5 shows the service termination stage messages.

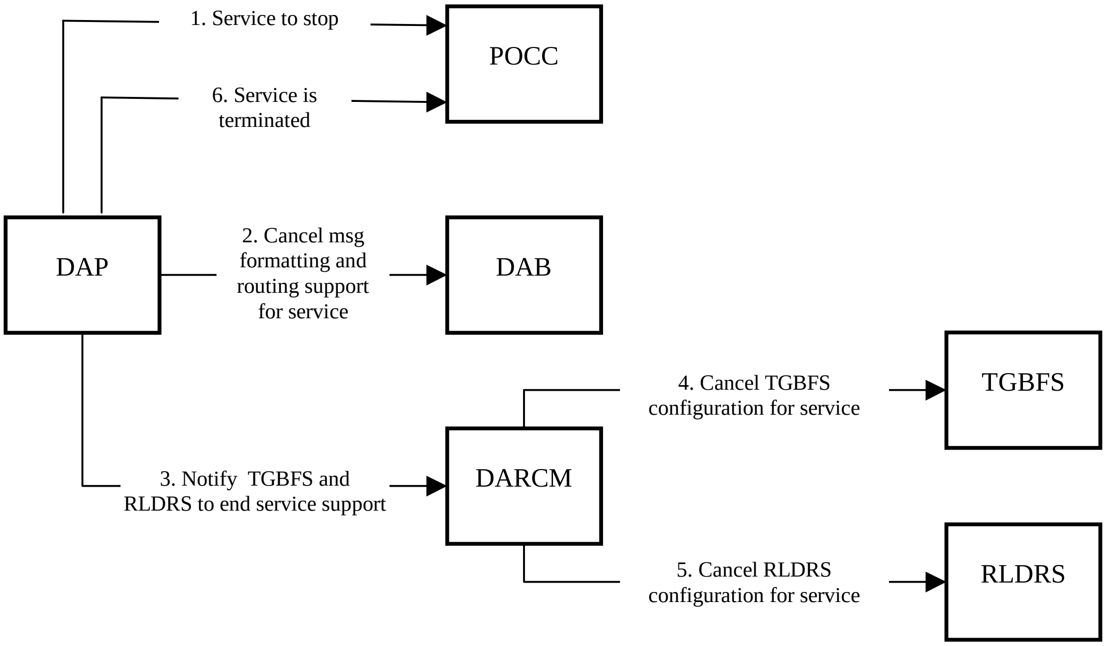

Figure 5-5: Service Termination Stage

The content of the messages exchanged in Figure 5-5 are as follows:

1. Notification to the POCC that the service requested earlier is about to terminate.
2. Terminate return data routing through the DAB to the designated POCC for this request.
3. Notification to DARCM to cancel TGBFS and RLDRS configuration for the service request.
4. Drop RLDRS support for the service request.
5. Drop TGBFS support for the service request.
6. Notification to the POCC that the requested DAR service is terminated.

6. ACRONYMS AND ABBREVIATIONS

BFS	Beam Forming System
DAB	Demand Access Buffer
DACDHS	Demand Access Control Data Handling Subsystem
DAF	Demand Access Forward
DAP	Demand Access Processor
DAR	Demand Access Return
DARCM	Demand Access Return Control/Monitoring
DAS	Demand Access System
GSFC	Goddard Space Flight Center
GT	Ground Terminal
IBU	Independent Beamformer Unit
IF	Intermediate Frequency
IOnet	NASCOM IP Operational Network
IP	Internet Protocol
kbps	kilobits per second
KSA	Ku-band Single Access
KSAF	Ku-band Single Access Forward
KSAR	Ku-band Single Access Return
MA	Multiple Access
MABE	Multiple Access Beamforming Equipment
MAF	Multiple Access Forward
MAR	Multiple Access Return
msg	message
NASA	National Aeronautics and Space Administration
NADCOM	NASA Communications
NCC	Network Control Center
PN	Pseudorandom Noise
POCC	Project Operations Control Center
RF	Radio Frequency
RLDRS	Return Link Data Recovery Subsystem
SGL	Space Ground Link
SGLT	Space Ground Link Terminal
SHO	Schedule Request Order
SN	Space Network
SRO	Service Reconfiguration Operation
SSA	S-band Single Access
SSAF	S-band Single Access Forward
SSAR	S-band Single Access Return
STDN	Spaceflight Tracking and Data Network
SV	State Vector
TDRS	Tracking and Data Relay Satellite
TDRS	Tracking and Data Relay Satellite System
TDM	Tracking Data Message
TGBFS	Third Generation Beamforming System
TUT	TDRS Unused Time

UP	User Platform
USAT	User Satellite
WSC	White Sands Complex